545

VOLUME 80 SEPARATE No. 545

PROCEEDINGS

AMERICAN SOCIETY
OF
CIVIL ENGINEERS

NOVEMBER, 1954

CAPITALIZING ON MUNICIPAL WASTES BY COMPOSTING

by Richard P. Stovroff

SANITARY ENGINEERING
DIVISION

{Discussion open until March 1, 1955}

Copyright 1954 by the AMERICAN SOCIETY OF CIVIL ENGINEERS
Printed in the United States of America

Headquarters of the Society
33 W. 39th St.
New York 18, N. Y.

PRICE $0.50 PER COPY

THIS PAPER

--represents an effort by the Society to deliver technical data direct from the author to the reader with the greatest possible speed. To this end, it has had none of the usual editing required in more formal publication procedures.

Readers are invited to submit discussion applying to current papers. For this paper the final date on which a discussion should reach the Manager of Technical Publications appears on the front cover.

Those who are planning papers or discussions for "Proceedings" will expedite Division and Committee action measurably by first studying "Publication Procedure for Technical Papers" (Proceedings – Separate No. 290). For free copies of this Separate—describing style, content, and format—address the Manager, Technical Publications, ASCE.

Reprints from this publication may be made on condition that the full title of paper, name of author, page reference (or paper number), and date of publication by the Society are given.

The Society is not responsible for any statement made or opinion expressed in its publications.

This paper was published at 1745 S. State Street, Ann Arbor, Mich., by the American Society of Civil Engineers. Editorial and General Offices are at 33 West Thirty-ninth Street, New York 18, N. Y.

CAPITALIZING ON MUNICIPAL WASTES BY COMPOSTING

Richard P. Stovroff[1]

Population growth and social trends of the past 15 years have intensified a problem that has constantly plagued our cities: a means of municipal waste disposal that will meet all sanitary requirements and still effect economies to halt the ever-increasing costs of disposal. Municipal officials are eagerly searching for some means of alleviating this burden.

Municipal waste disposal is not a new question. It is a problem of sanitation which dates back to our earliest communities. It has grown in intensity and complexity as these communities have grown. Yet very little research, experimentation and development have been done on the subject. We are still using, at best, only refinements of the basic methods of garbage disposal that have been used for centuries: dumping and incineration.

There are as many forms of these two methods as there are disposal sites; some are relatively primitive, and others are highly refined. Little effort has been expended to develop better means of municipal waste disposal. Economic pressure has espoused the recent interest in composting of municipal and industrial waste as a means of disposal. As a method of disposal, composting is new. It approaches the disposal problem in a different light and on a positive basis, one that can convert what heretofore has been a liability into an asset.

Disposal by composting is new in the United States. Historically, composting has been considered simply in terms of increased fertility. It is now necessary to view composting as a method of municipal refuse disposal, as well as a way of increasing agricultural yields. Until recently, commercial composting has had an unsavory reputation in sanitary, agricultural and other scientific circles. For years, its proponents have made assorted claims that were bounded only by the limits of their imagination. As a natural reaction, compost's detractors have been equally imaginative and inaccurate.

Existing literature on commercial composting is full of opinion but woefully short of facts. Only in the last few years have experimental and commercial operations determined the essentials of composting as a daily operation.

Recent experience of the Compost Corporation of America makes it evident that composting can be a valuable part of our fertilizer industry. It is, today, perhaps the least developed of any part of the fertilizer industry. Composting will undoubtedly assume a growing importance in the industry, an industry which has just begun to develop. Fertilizer accomplishments in the next 50 years will pale the outstanding results of the past.

For successful commercial composting, proper facilities must be established to control and intensify the natural biological actions. The operation of the experimental plant of the Compost Corporation of America proved that a successful commercial operation is essentially a matter of materials handling. The conversion is biological, but profits are contingent upon mechanical efficiency.

---

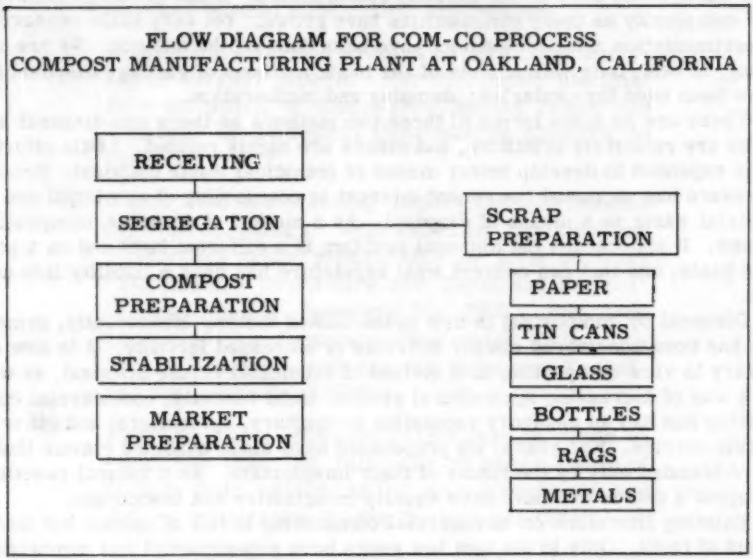
1. Compost Corp. of America, San Francisco, Calif.

Plant design must be determined after careful study and interpretation to cope with the varying local factors, even though basic precepts and phases will be similar. The process is simple and should be done scientifically to obtain the greatest operating efficiency. There must be a dollars-and-cents justification of each operational step. It is a business endeavor and must be run as such to produce a profit.

Experience in operating the Oakland plant has proven composting should comprise only the following basic operational phases:

1) Receiving.
2) Segregation and scrap preparation.
3) Compost preparation.
4) Decomposition or stabilization.
5) Market preparation.

A flow diagram for Com-Co process is shown below.



Messrs. P. H. McGauhey and Harold B. Gotaas (Proceedings—Separate 302) have previously presented a paper on the more technical details of composting. This discussion and description, therefore, will be limited to the general operational aspects.

Receiving is common to any garbage disposal method. There is the obvious necessity to bring the refuse to a central point for disposal processing, whether it is composting, incineration or landfill.

The second phase, segregation and scrap preparation, is necessary only where there are mixed refuse collection systems, as exist in Oakland. The compostable and non-compostable materials must be separated. This may be done either before or after compost preparation and decomposition. This entire step can be eliminated where table waste and rubbish are collected separately. In Oakland, it is most effective to separate prior to composting and decomposition, since it reduces the handling costs and still facilitates the preparation of all materials for market.

Separated organic materials are blended with those which do not require separation. They are then processed under controls which insure relative uniformity and conditions conducive to the intensive micro-biological action desired. From here, the material moves to the stabilization phase, and the process becomes almost automatic, requiring little equipment or processing effort.

Decomposition of the processed organics takes place in the open air upon unimproved land. The material is placed in long windrowed piles where it remains from three to four weeks. It is here that the micro-organisms become the laboring force which transforms the waste into marketable compost. Unlike most processing, this requires only the labor necessary for maintenance of controls to insure biological stabilization. Natural elements such as micro-organisms, air and land effect the great economy in this type of processing.

The time requirements mentioned could be reduced, but only with the expenditure of additional labor. But there is no commercial advantage to this, since compost is sold in agricultural markets which are spasmodic and require provisions for handling surges. To expend monies to rush the completion of a product which will then be held in inventory is economically unsound. It would result in additional costs for warehousing and the tie-up of working capital. Thus, windrowed composting both provides the opportunity to hold the surges of materials needed for the agricultural market as an integral part of the production process and virtually eliminates processing labor.

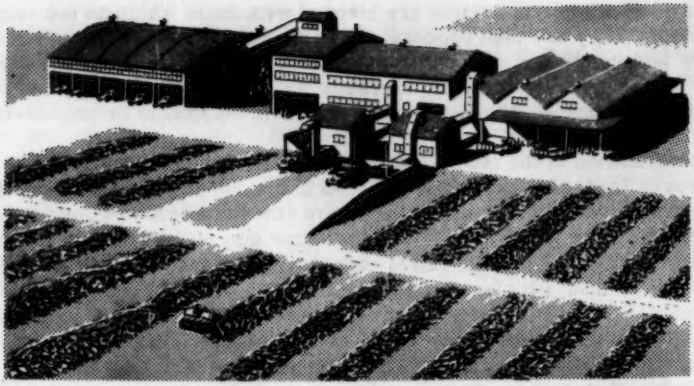
These open-aired windrowed piles meet all desired sanitary and public health standards. Moreover, experience indicates that they will prove satisfactory under all climatic conditions. The nature of the piles and the material in them creates their own insulation. The internal temperature created by the biological fermentation can be maintained under even freezing conditions. In areas with excessive moisture, this problem of moisture control is overcome. No economic justification for increasing either equipment or operation costs of this particular phase for sanitation standards, climate or speed of decomposition has yet been found.

Market preparation is the final step. The material is processed as it is needed to meet the consumers' approval. The exact form of the processing will be dependent upon local climatic conditions, customs, agricultural practices, types of crops and other factors. For example, in California a broader market and greater consumer acceptance are effected if the compost is supplemented with nitrogen. Varying conditions and practices throughout the country make it difficult to predict the exact form this market preparation may take in a particular area.

These basic phases of composting operation are applicable anywhere. Experience in Oakland as well as with other groups, however, has established that no two composting plants can be identical. The sketch on the following page shows the over-all plant layout for Oakland.

We believe composting can be carried on wherever the volume of waste generated is great enough to warrant the capital investment and to cover general business overhead. All local conditions must be considered in planning the original facilities to insure the necessary low costs. And careful studies should be made by composting experts before any construction is begun. The differences in raw materials, climate and usage, must be given careful consideration, in order to obtain optimum operating efficiency. Although these variables dictate differences in the equipment and its placement in the various installation, the basic operational phases will hold.

The importance of cost in production of a low-priced bulk commodity cannot be over emphasized. Since quantity applications are most effective, compost



must be sold at a low cost-per-ton. Acceptance in the general market requires pricing at a fraction of the $60.00 to $100.00 per ton range commonly associated with compost materials. Most previous attempts at composting have been small-scale, with widely scattered sales to only the highly specialized markets that could absorb the high price. Large scale composting must appeal to a wide market. Composting is a tonnage operation and must be accomplished with a minimum of production costs to insure profits at a low market price.

To illustrate the advantages of a well planned and designed composting plant from an economic standpoint, it will be helpful to examine the figures for the new Oakland operation. These figures, unfortunately, are for this plant only and can do no more than indicate what might be done in other areas. They should not be transferred directly, as the details must be tailored to the particular site and local conditions.

The Oakland plant was designed to dispose of 265 tons of refuse on an eight-hour-day, five-day-a-week basis.

Table No. I ESTIMATE OF COST

ITEM	AMOUNT	TOTAL
Buildings	$ 200,000	$
Equipment	310,000	
Facilities & Costs	80,000	590,000
Working Capital		125,000
CAPITAL INVESTMENT		$ 715,000

Table I of the printed copy shows total building requirements of $200,000.00, with equipment requirements of $310,000.00, and other facilities of $80,000.00, or a total installation expense of $590,000.00. Working capital required to carry on the successful operation is $125,000.00, bringing total capital investment to $715,000.00

The disposal of 265 tons of refuse per day produces 125 tons of compost and 80 tons of marketable scrap materials.

Table No. II FORECAST OF OPERATIONS for Twelve-Month Period of Normal Operations		
ITEM	AMOUNT	TOTAL
SALES		
Compost Fertilizer	$1,200,000	$
Scrap	255,000	
		1,455,000
COSTS		
Processing Costs	740,000	
Technical & Control Expense	12,000	
Selling & Advertising	172,000	
Admin. & General Expense	51,000	
		975,000
PROFIT BEFORE FEDERAL TAXES ON INCOME (Excluding Excess Profit Tax)		$ 480,000
PROVISION FOR FED. TAXES ON INCOME (Excluding Excess Profit Tax)		245,000
NET PROFIT		$ 235,000
RETURN ON INVESTMENT OF $715,000		32%

Table II shows a condensed forecast of operation for a normal year. Annual sales are $1,200,000.00 for the compost fertilizers, and $255,000.00 for scrap or secondary raw materials which are removed from the refuse, or a total sales revenue of $1,455,000.00 per year. Processing costs are $740,000.00. Technical and control expenses are $12,000.00. Selling and advertising costs are $172,000.00, and administrative and general expenses are $51,000.00. Total cost is $975,000.00. Gross profit for the year's operation is $480,000.00. A provision for federal income tax of $245,000.00 leaves a net profit of $235,000.00. This return is over 30 percent on the total investment of $715,000.00.

Table III outlines direct labor cost and other direct production costs for the disposal of 265 tons per day of refuse. Receiving and separation runs 0.91 per ton, compost preparation 0.31, stabilization 0.27, and finishing 0.46. Direct labor costs, applicable to composting $1.95 per ton. Scrap costs 0.50 per ton. Total direct labor cost is $2.45 per ton of refuse disposal. Power costs are 0.11. Water costs are 0.02, and maintenance costs are 0.32. These figures do not include processing overhead, such as fuel and lubricants, depreciation, property taxes, plant manager and office, and other miscellaneous expenses, which are included in the total processing cost shown in Table II.

It is assumed the garbage would be delivered to the plant site without cost. Were a private group to establish facilities to perform this disposal service for a municipality, they should be paid for this service. In other cases, where these facilities are built and operated by the municipality, the revenue from disposal of the waste could be used to defer a portion of the collection cost.

It is important to bear in mind that these are the figures for Oakland, California, and should serve only as a yardstick for other communities. This

Table No. III DIRECT LABOR COSTS (Per Ton of Refuse Disposed)		
ITEM	AMOUNT	TOTAL
DIRECT LABOR COST APPLICABLE TO COMPOST:		
Receiving & Separation	$ 0.91	$
Compost Preparation	0.31	
Stabilization	0.27	
Market Preparation	0.46	1.95
DIRECT LABOR COST APPLICABLE TO SCRAP		0.50
DIRECT LABOR COST PER TON OF REFUSE DISPOSED		$ 2.45
OTHER PRODUCTION UNIT COSTS		
Power	$ 0.11	
Water	0.02	
Maintenance	0.32	$ 0.45

plant is undoubtedly the forerunner of a whole series; it is the Model T of composting. And like the Model T, this plant is the forerunner of a better and more efficient way of performing an economic function. It is a profitable operation, but is only a beginning.

Table No. IV COMPARATIVE AVERAGE COSTS of DISPOSAL by INCINERATING AND COMPOSTING (265 Tons per day - 5 day Week)		
ITEM	INCINERATING	COMPOSTING
BUILDING AND EQUIPMENT COST PER TON OF CAPACITY	$ 4,500.00	$ 2,000.00
COST OF OPERATION PER TON INCLUDING FIXED CHARGES	4.00	-0-
COST OF OPERATION PER YEAR INCLUDING FIXED CHARGES	259,000.00	976,000.00
ANNUAL GROSS REVENUE	-0-	1,455,000.00
ANNUAL GROSS PROFIT (OR LOSS)	(259,000.00)	478,000.00
ANNUAL DIFFERENCE BETWEEN PROCESSES		$ 737,000.00

Table IV compares the capital requirements and costs for both composting and incinerating 265 tons of refuse per day. Composting produces approximately one-half million dollars of revenue per year, while incineration incurs expenses of about one-quarter of a million. This is an annual difference of three-quarters of a million dollars and is realized from a capital investment that is approximately one-half that required for incineration.

The other common method of refuse disposal, landfill, has proved the most successful in this country to date. However, there are many who fear the possibility of contamination from these dump sites. Landfill has a tendency to build unsightly mountains of garbage and earth. Time and population concentration are rapidly destroying the former advantages of landfill disposal. Scarcity of land will eventually force dump and fill areas to consider other means. And the required investment, though still relatively low, is rapidly increasing. As the diminishing availability of dump sites forces these further from the city, the cost of their operation mounts. Landfill, too, is a matter of constant cost, while composting produces profit.

Why, with the disadvantages of dumps and incinerators and advantages of composting, has composting not been successful before? Why have all previous composting attempts in the United States failed? Careful examination of American composting history shows two basic reasons.

1) Lack of scientific and economic know-how.
2) Poor timing.

The Sanitary Engineering Research Project published by the University of California in its Bulletin #9 dispells the many misconceptions about composting and determines the basic principles involved. In conjunction with the Office of J. Fruchtbaum, Consulting Engineers, the Compost Corporation of America has refined the operational know-how developed at Oakland. This study was the basis of the engineering and financial reports which offer the first valid economic evaluation of composting.

These two recent efforts, one from an academic-analytical appraoch, the other economic-mechanical, have reached similar conclusions. They have made available realistic information to a field which until now has been too heavily burdened with opinion.

Thus, the first great hurdle, lack of scientific and economic data, has been overcome.

But knowledge itself is valueless until there is a need for it. It must be utilized. The growth of our cities and their suburban areas has increased the burden of disposal. New means of disposal must be found; the problem is growing daily. The expansion of the United States and its industrial and agricultural economies have today reached a point which necessitates the full utilization of both the scrap materials and organic refuse being destroyed by our present methods of garbage disposal. America's natural development has thus created a great potential market for both the services performed and products produced by composting. These changed conditions have negated the second obstacle of poor timing.

The pressing need for a new and economic method of municipal waste disposal is evident. The know-how is available. The path is now clear for composting.

The United States has been endowed with great natural resources, but because of this abundance we have never learned how best to utilize them. We have already squandered a huge part of this tremendous wealth. We are faced today with the frightening truth that a considerable part of our natural wealth has already been consumed. Yet the need for raw materials to feed our giant industrial appetite is today greater than ever before. However, we cannot hope

to find great additional prime sources of minerals and fibers, the raw materials of our basic industries.

The economics of composting permits the removal of the 20 to 30 per cent of refuse that is secondary raw materials. This additional source of raw materials can be used to feed the nation's economic bloodstream. Without the ability of composting to convert garbage into usable materials, these vitally important minerals and fibers would continue to be destroyed.

Another disturbing factor facing America's continued growth is the disappearance of our historical frontier. We can no longer find new, virgin agricultural lands to the West. We are, therefore, forced to increase the yield of our presently cultivated lands.

Today we have 400,000,000 acres of crop land, much the same area we had 30 years ago. Our percentage of farm population in 1920 was 30 per cent. Today, it is only 15 per cent and still shrinking. Our expected population of 200,000,000 in 1975 will have to be fed from 2.2 acres per person, compared to 2.5 today and 4.2 in 1900. Each farmer who is today feeding 15 people will have to feed 20. The United States Department of Agriculture estimates that we will need the equivalent production of 100,000,000 acres of land by 1975. If all reclamation and irrigation projects contemplated are completed, we shall be able to obtain 30,000,000 additional acres. This leaves a deficit of 70,000,000 acres yield.

These demands will require a great increase in yield per acre which can be met only with improved and well-balanced farm practices. The major methods are mechanization and fertilization. Great progress has already been effected with mechanization; it is unlikely that the future will offer more than refinements. Fertilization then will have to assume the bulk of this responsibility. Modern agricultural yields would be impossible without the soluble salts of our giant synthetic chemical fertilizer industry. But though we will need even greater quantities of these chemicals, they are only one source of nutrients and only one part of a balanced fertilization program.

Dr. Myron S. Anderson, Senior Chemist, Bureau of Plant Industry, United States Department of Agriculture, Experimental Station Beltsville, Maryland, has stated in the "Year Book of Agriculture" 1950 - 51, "Great areas of our soil produce best when both organic manures and chemical fertilizers are applied, not just one or the other." This has been reiterated by a recent publication of the National Fertilizer Association which stated, "Even when fertilizers are used liberally, organic matter is needed to make their use efficient—the two are in a working partnership."

Compost or organics are necessary in sound, well-balanced cultivation and fertilization practices. A part of the organics that we need can be supplied by municipal waste. This great untapped source of humus organic matter is now being destroyed. Organics or humus have long been recognized as the life-giving part of our soil.

According to Dr. Selman A. Waksman of Rutgers, "The importance of humus in human economy seldom receives sufficient emphasis. Suffice to say that it probably represents the most important source of human wealth on this planet."

In spite of this importance, our interest in organic matter has waned in the past 50 years. A variety of factors have brought about this disinterest. The remarkable results obtained by the initial use of chemicals induced heightened activity in that field. Moreover, the replacement of domestic animals by machinery has reduced the major source of organics. These factors have relegated organics other than green manures, to a secondary position.

Experience indicates that consistent and intensive use of chemicals reaches a point of diminishing return. Compost has been so limited in supply that little

attention has been paid to it as a source of organic humus. Recent trends in agriculture have shown that even the maintenance of our present fertility will require more intensive use of organics. The pendulum is returning from its violent swing to exclusive concentration on chemicals to a better balanced fertilization program. Agronomists now acknowledge that compost helps agricultural production by performing these functions:

1) Improving soil structure.
2) Increasing availability of plant nutrients.
3) Increasing effectiveness of chemical fertilizer.
4) Furnishing a source of additional nutrients.
5) Furnishing a source of minor elements and trace minerals.
6) Increasing moisture holding capacity.
7) Preventing leaching of soil minerals.
8) Maintaining soil balance.
9) Providing food and housing for soil micro-biological life.
10) Helping to prevent erosion.

The limited production of compost has been restricted primarily to the composting of stable straws and manures. The product from this source is inferior, since it was produced under uncontrolled conditions and did not have the heterogeneous base afforded by garbage. It would be unreasonable to judge the compost produced under scientific controls from the rich waste of our cities on the basis of these previous products. The importance of compost can be seen by examining the results obtained in areas of the world with a long history of using compost.

Nations without this country's former high ratio of land area per capita have already been obliged to use their municipal waste. The United States is now approaching that intensity of population. The Netherlands provides an example of similar agricultural conditions. A twenty year history of composting in the Netherlands, by the N. V. Vuilafvoer Maatschappij "V.A.M." which process the refuse of the Hague, proves conclusively that there is a place in modern intensive agriculture for municipal composts. According to Mr. W. A. G. Westrate, Director of "V.A.M." the average increase in yield from the continual use of compost has been 20 percent. The use of both compost and fertilizer has consistently produced some of the world's top yields. It should be pointed out, however, that municipal compost in the United States would be more effective, since municipal garbage in the Netherlands is almost wholly devoid of rich table waste.

The pressing problem of how best to dispose of the nation's municipal waste has been answered. The answer is consonant with all sanitary requirements. It converts the staggering cost of disposal into a considerable source of revenue. Moreover, it salvages presently wasted secondary raw materials and provides an urgently-needed means to increase agricultural production.

All of the obstacles retarding the evolution of this answer have been erased. The myths have been dispelled. The scientific and economic data has been compiled and refined. The answer has been tested and proven.

The answer is composting.

AMERICAN SOCIETY OF CIVIL ENGINEERS

OFFICERS FOR 1955

PRESIDENT

WILLIAM ROY GLIDDEN

VICE-PRESIDENTS

Term expires October, 1955:
ENOCH R. NEEDLES
MASON G. LOCKWOOD

Term expires October, 1956:
FRANK L. WEAVER
LOUIS R. HOWSON

DIRECTORS

Term expires October, 1955:
CHARLES B. MOLINEAUX
MERCEL J. SHELTON
A. A. K. BOOTH
CARL G. PAULSEN
LLOYD D. KNAPP
GLENN W. HOLCOMB
FRANCIS M. DAWSON

Term expires October, 1956:
WILLIAM S. LaLONDE, JR.
OLIVER W. HARTWELL
THOMAS C. SHEDD
SAMUEL B. MORRIS
ERNEST W. CARLTON
RAYMOND F. DAWSON

Term expires October, 1957:
JEWELL M. GARRELTS
FREDERICK H. PAULSON
GEORGE S. RICHARDSON
DON M. CORBETT
GRAHAM P. WILLOUGHBY
LAWRENCE A. ELSENER

PAST-PRESIDENTS

Members of the Board

WALTER L. HUBER
DANIEL V. TERRELL

EXECUTIVE SECRETARY
WILLIAM N. CAREY

TREASURER
CHARLES E. TROUT

ASSISTANT SECRETARY
E. L. CHANDLER

ASSISTANT TREASURER
GEORGE W. BURPEE

PROCEEDINGS OF THE SOCIETY

HAROLD T. LARSEN
Manager of Technical Publications

DEFOREST A. MATTESON, JR.
Editor of Technical Publications

PAUL A. PARISI
Assoc. Editor of Technical Publications

COMMITTEE ON PUBLICATIONS

SAMUEL B. MORRIS, *Chairman*

JEWELL M. GARRELTS, *Vice-Chairman*

GLENN W. HOLCOMB
OLIVER W. HARTWELL
ERNEST W. CARLTON
DON M. CORBETT